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In re Patent Application of:		)	
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Kaoru Ishida, et al.		)	Examiner: To Be Assigned
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Serial No. :	To Be Assigned	)	Group Art Unit: To Be Assigned
		)	
Filed:	Herewith	)	

For : POWER SPLITTER/COMBINER MULTI-LAYER CIRCUIT

PRELIMINARY AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Prior to calculation of filing fees for the above-identified divisional application, please amend the application as set forth below:

IN THE SPECIFICATION:

Page 1, on the line after the title of the invention, please insert the following paragraph:

--CROSS REFERENCE TO RELATED APPLICATION

This application is a division of Serial No. 10/102,732, filed March 22, 2002, which is a division of Serial No. 09/758,427, filed January 12, 2001 (U.S. Patent No. 6,563,395), which is a division of Serial No. 09/050,012, filed September 9, 1998 (U.S. Patent No. 6,201,439), each application being incorporated herein, in their entirety, by reference.- -

On Page 1, Second Full Paragraph Bridging Pages 1 and 2:

A high power amplifier capable of propagating several tens of watts to several hundreds of watts has recently been used at a digital mobile communication base station. This kind of high power amplifier comprises a plurality of push-pull amplifiers combined in parallel to obtain high power, wherein each push-pull amplifier comprises two ~~same~~ identical transistors connected in parallel and supplied with signals 180 degrees out of phase with respect to each other. The explanation of the push-pull amplifier has been given on pages 113 to 116 of "Radio Frequency Transistors" written by Norm Dye and Helge Granberg, published by Butterworth/Heinemann. Therefore, no detailed explanation is given here. This power amplifier circuit requires a power splitter/combiner circuit and baluns at each of the input and output of the circuit.

On Page 2, First Full Paragraph Bridging Pages 2 And 3:

A conventional high power amplifier will be described below referring to FIG. 11. In FIG. 11, the numeral 501 designates a n-way power splitter, the numeral 502 designates a n-way power combiner, and the numerals 503, 504 designate n baluns, and the numeral 505 designates n pairs of push-pull amplifiers. A power splitter/combiner circuit used in this configuration will be described below referring to FIGS. 12A, 12B and 13. FIGS. 12A, 12B and 13 show the configurations of Wilkinson power splitter circuits. FIG. 12A shows a general Wilkinson power splitter circuit. The numeral 601 designates an input terminal, the numeral 602 designates n quarter-wavelength lines, the numeral 603 designates n isolation resisitors, and the numeral 604 designates n output terminals. FIG. 12B shows a tree

[confitguration] configuration of [2] two-way-splitters capable of being configured as a plane circuit. The numeral 605 designates an input terminal, the numeral 606 designates two quarter-wavelength lines, the numeral 607 designates an isolation resisitor, the numeral 608 designates four quarter-wavelength lines, the numeral 609 designates two isolation resisitors, and the numeral 610 designates four output terminals. In addition, FIG. 13 shows an asymmetric power splitter type. The numeral 611 designates an input terminal, the numerals 612, 613, 616 and 617 designate quarter-wavelength lines having characteristic impedances different from one another, the numerals 614 and 618 designate isolation resisitors, and the numeral 615, 619 and 620 designate impedance transformer circuits. The explanation of Wilkinson power combiner circuit has been given on pages 205 to 210 of "Foundations of Microwave Circuits and Applications thereof" written by Yoshihiro Konishi, published by Sogo Denshi. Therefore, no detailed explanation is given here.

On Page 4, Last Paragraph Bridging Pages 4 And 5:

In the high power amplifier in accordance with the present invention, a Wilkinson power splitter for more splits, having been difficult to be attained as a plane circuit, is attained by using a multilayer b and by connecting isolation resisitors to a common terminal via a through hole. In addition, a balun been configured by using a coaxial line, is configured by using a multilayer board and by providing coupling lines on the layers above and below a strip line, thereby to obtain two opposite-phase outp With this configuration, power splitter/combiner circuits and baluns can be formed on a single mult board, whereby the high power amplifier circuit can be miniaturized drastically. In addition, since t balun can propagate two opposite-Phase outputs, the number of splits can be reduced, whereby the

size of the splitter can be made smaller. In addition, since n-splitting/n-combining functions can be out at one time, loss can be reduced, whereby the efficiency of the power amplifier can be improved

On Page 5, Second Full Paragraph:

In order to attain the objects, the present invention [O]offers such a high power amplifier having:

On Page 5, Last Paragraph Bridging Pages 5 And 6:

a first balun propagating a half of an input signal to an in-phase output terminal, and also propagating a fourth of [said] the input signal to first and second opposite-phase output terminals, [said] the signal propagated to [said] the first and second opposite-phase output terminals lagging 180 degrees behind [said] the signal propagated to [said] the in-phase output terminal;

On Page 6, Beginning With The First Full Paragraph:

first and second power amplifier circuits connected to [said] the first and second opposite-phase output terminals of [said] the first balun and having [the same] identical characteristics;

a third power amplifier circuit connected to [said] the in-phase output terminal of [said] the first balun and having output power substantially twice as much as the output power of [said] the first or second power amplifier circuit; and

a second balun having first and second opposite-phase input terminals for receiving the outputs of [said] the first and second power amplifier circuits, having an in-phase input

terminal for receiving the output of said third power amplifier circuit, combining [said] the outputs of [said] the first, second and third power amplifier circuits, and propagating combined output.

On Page 7, Beginning With Second Full Paragraph:

FIG. 4A is a sectional view showing a [power 4-splitter] four-way power splitter for the high power amplifier in accordance with the second embodiment; FIG. 4B is a view showing the conductor patterns of the [power 4-splitter] four-way power splitter; and FIG. 4C is a circuit diagram of the [power 4-splitter] four-way power splitter.

FIG. 5 is a view showing the conductor patterns of a six-way power [6-]splitter in accordance with another example of the second embodiment;

On Page 8, Beginning With Second Full Paragraph:

FIG. 12A is a circuit diagram of a general Wilkinson power splitter; and FIG. 12B is a circuit diagram of a one-input, multi-splitter comprising a Wilkinson [power 2-splitter] two-way power splitter;

301, 302 [power 4-splitters] four-way power splitters

On Page 9, In The Last Paragraph Bridging Pages 9 And 10:

FIG.1 is a view showing the configuration of a high power amplifier in accordance with a first embodiment of the present invention. Referring to FIG. 1, the numerals 101, 102

designate baluns, the numerals 103, 104 designate power amplifiers having [the same] identical characteristics, the numeral 105 designates a power amplifier generating output power twice as high as that of the power amplifier 103 or 104, the numeral 106 designates an input terminal, and the numeral 107 designates an output terminal.

On Page 10, Last Paragraph Bridging Pages 10 And 11:

Referring to FIG. 2A, the numerals 201, 202, 203 [to 203] designate first to third conductor pattern layers, and the numerals 204, 205 designate first and second dielectric layers. Referring to FIG. 2B, the top drawing shows the first conductor pattern layer 201, the middle drawing shows the second conductor pattern layer 202, and the bottom drawing shows the third conductor pattern layer 203. The numeral 206 designates an input terminal provided on the second conductor pattern layer 202, to which signals are input. The numeral 207 designates a main line connected to the input terminal. At the other end of the main line, a first through hole 212 is formed. The numeral 208 designates a first coupling line provided on the first conductor pattern layer 201. The numeral 209 designates a second coupling line provided on the third conductor pattern layer 203. The main line and the coupling lines are formed at positions so as to be in face-to-face relationship with one another, and are coupled electromagnetically. The numeral 210 designates a first grounding conductor provided on the first conductor pattern layer 201, and the numeral 211 designates a second grounding conductor provided on the third conductor pattern layer 203. The grounding conductors 210, 211 are connected to the coupling lines 208, 209, respectively. The numeral 212 designates the first through hole formed at the other end of the main line

207, and the numeral 213 designates a second through hole formed at the other end of the second coupling line 209. The numeral 214 designates an in-phase output terminal formed on the first conductor pattern layer 201 and connected to the first through hole. The numeral 215 designates a first opposite-phase output terminal formed at the other end of the first coupling line 208 on the first conductor pattern layer 201. The numeral 216 designates a second opposite-phase output terminal formed on the first conductor pattern layer 201 and connected to the second through hole 213. Referring to FIG. 2C, the numeral 217 designates an input terminal, the numeral 218 designates a main line, the numerals 219, 220 designate first and second coupling lines, respectively. The numeral 221 designates an in-phase output terminal. The numerals 222, 223 designate first and second opposite-phase output terminals, respectively.

On Page 12, Second Full Paragraph Bridging Pages 12 and 13:

FIG. 3 is a view showing the configuration of a high power amplifier in accordance with a second embodiment of the present invention. Referring to FIG. 3, the numerals 301, 302 designate [power 4-splitters] four-way power splitter/combiners, the numeral 303 designates the high power amplifier described in the explanation of the first embodiment, the numeral 304 designates an input terminal, and the numeral 305 designates an output terminal.

Page 13, First Full Paragraph:

In this configuration, the [power 4-splitter] four-way power splitter combiners used

for the present invention will be detailed below referring to FIGS. 4A to 4C. FIG. 4A is a sectional view showing the four-way power [4-]splitter/combiners formed of a dielectric multilayer board. FIG. 4B is a view showing the conductor patterns on the conductor pattern layers of the board. FIG. 4C is a circuit diagram of the [power 4-splitter] four-way power/splitter combiners. Referring to FIG. 4A, the numerals 401, 402, 403 [to 403] designate first to third conductor pattern layers, and the numerals 404, 405 designate the first and second dielectric layers. Referring to FIG. 4B, the numeral 406 designates an input terminal, the numerals 407, 408, 409, 410 [to 410] designate first to fourth quarter-wavelength lines, the numerals 411, 412, 413, 414 [to 414] designate first to fourth isolation resisitors, the numeral 415 designates a first through hole, the numeral 416 designates a common terminal, the numerals 417, 418, 419 [to 419] designate second to fourth through holes, the numeral 420 designates a shield conductor, and the numerals 421, 422, 423, 424 [to 424] designate first to fourth split output terminals. Referring to FIG. 4C, the numeral 425 designates an input terminal, the numeral 426 designates quarter-wavelength lines, the numeral 427 designates isolation resisitors, and the numeral 428 designates split output terminals.

Page 14, First and Third Paragraph:

[Furthermore] Returning to FIG. 4B, the numeral 407a designates an end of the first quarter-wavelength line 407, away from the input terminal 406. The numeral 408a designates an end of the second quarter-wavelength line 408, away from the input terminal ~~406~~ 406. The numeral 429a designates a first output line, and the numeral 429b designates

a second output line.

A method of embodying a non-planer Wilkinson four-way power [4-] splitter shown in FIG. 4C by using the dielectric three-layer board shown in FIG. 4A will be described below.

Page 15, First Full Paragraph:

Furthermore, the shield conductor 420 [hollowed around] surrounding the through holes [are] is provided on the second conductor pattern layer 402 (see Fig. 4A) between the first conductor pattern layer 401 and the third conductor pattern layer 403 to prevent signal interference between the first conductor pattern layer 401 and the third conductor pattern layer 403. The [power 4-] four-way power splitter having the above-mentioned structure and the balun disclosed in the first embodiment are used to form a high power amplifier on the same dielectric multilayer board. Consequently, the number of components in the high power amplifier of the present embodiment can be made less than the number of components in a conventional high power amplifier comprising two [power 8-splitter] eight-way power splitter circuits ~~(14 power 2-splitters)~~ and 16 baluns, whereby the circuit can be made smaller. Moreover, since ~~4-splitting and 4-combining~~ four way splitting and four way combining are carried out at one time, loss can be reduced, and the efficiency of the power amplifier can be improved.

Page 15, Last Paragraph Bridging Pages 15 and 16:

The power splitter used in the above-mentioned second embodiment is a ~~power 4-~~

~~splitter~~ four-way power splitter type. However, four or more splits can be attained as desired by increasing the number of layers of the dielectric board. A [power 6-splitter] six-way power splitter circuit formed of a dielectric five-layer board is shown in FIG. 5 as an example.

Page 16, First Full Paragraph

Referring to FIG. 5, the numeral 451 designates an input terminal, the numerals 452, 453, 454, 455, 456, 457 [to 457] designate first to sixth quarter-wavelength lines, the numerals 458, 459, 460, 461, 462, 463 [to 463] designate first to sixth isolation resisitors, the numeral 464 designates a first through hole, the numerals 465-a, 465-b designate common terminals, the numerals 466, 467, 468, 469, 470, 471, 472 [to 472] designate second to eighth through holes, the numeral 473, 474 designate first and second shield conductors, and the numerals 475, 476, 477, 478, 479, 480 [to 480] designate first to sixth split output terminals.

Page 16, Second Full Paragraph Bridging Pages 16 and 17:

With this configuration, just as in the case of the four-way power splitter [4-split] circuit of the second embodiment, a signal input from the input terminal 451 is split and propagated to six quarter-wavelength lines 452, 453, 454, 455, 456, 457 [to 457] via the first through hole 464. Furthermore, the other ends of the quarter-wavelength lines 452, 453, 454, 455, 456, 457 [to 457] are connected to the common terminal 465-a and the common terminal 465-b connected to the common terminal 465-a via the second through hole 466, by

means of the first to sixth isolation resisitors 458, 459, 460, 461, 462, 463 [to 463], respectively. The isolation resisitors 460, 461 for the third conductor pattern layer are taken out to the first conductor pattern layer via the third and fourth through holes 467, 468 respectively and connected to the common terminal 465-a. Although the third and fourth isolation resisitors 460, 461 are taken out to the first conductor pattern layer in the above description, the same circuit can be obtained when the resistors are taken out to the fifth conductor pattern layer and connected to the common terminal 465-b.

Page 17, First Full Paragraph:

Furthermore, by expanding this structure, a power splitter having a given number of splits can be formed. With this structure, just as in the case that the [power 4-splitter] four-way power splitter circuit in accordance with the second embodiment is used, a high power amplifier having a large split number can be made smaller, and the number of components thereof can be reduced, whereby the efficiency of the power amplifier can be further improved.

Page 18, Second Full Paragraph:

FIG. 6 is a view showing the configuration of a balun in accordance with a third embodiment of the present invention. Referring to FIG. 6, the numerals 1010, 1020 designate first and second dielectric layers, the numeral 1030 designates an input line, the numeral 1040 designates a main line, the numeral 1050, 1060 designate first and second coupling lines, the numerals 1070, 1080 designate first and second output line pairs, the

numerals 1090, 1100 designate first and second through holes, and the numerals 1110, 1120, 1130 [to 1130] designate first to third grounding conductors. ~~It is supposed~~ Consider that the first to third grounding conductors 1110, 1120, 1130 [to 1130] have been electrically connected to one another via through holes or the like (not shown). Among the above-mentioned electrodes and lines, the electrodes and lines disposed on the same plane form each of layers, and these layers correspond to the conductor pattern layers in accordance with the present invention. These conductor pattern layers are alternately stacked with the first and second dielectric layers to form the multilayer in accordance with the present invention

Page 19, First Full Paragraph Bridging Pages 19 and 20

When a radio-frequency signal is input to the input line 1030, electromagnetic couplings occur between the main line 1040 and the first coupling line 1050 and between the main line 1040 and the second coupling line 1060, the first and second coupling lines 1050, 1060 being disposed adjacent to the main line 1040. When the two couplings ~~has~~ have the same coupling degree, the radio-frequency signal is equally split and sent to the first and second coupling lines 1050, 1060. The split signal is further split into two equal signals, and the two signals are propagated to the two lines of the first output line pair 1070 connected to both ends of the first coupling line 1050, respectively. The two signals are 180 degrees out of phase with each other. In the same manner, two equally split radio signals 180 degrees out of phase with each other are also propagated to the two lines of the second output line pair 1080 connected to both ends of the second coupling line 1060, respectively. In other words, the balun circuit shown in FIG. 6 has the functions of a [power 2-splitter] two-way

power splitter as well as the functions of a balun. In addition, the coupling degree between the main line 1040 and the first and second coupling lines 1050, 1060 is determined depending on the dielectric constant and thickness of the first dielectric layer between the main line 1040 and the first and second
coupling lines 1050, 1060, and the widths of the main line 1040 and the first and second coupling lines 1050, 1060.

Page 20, First and Second Full Paragraphs:

With the configuration shown in FIG. 6, the circuit can be made [further smaller drastically] even smaller in comparison with the configuration wherein the splitter (combiner) and the balun are formed independently of each other.

It has been described that two coupling lines are used in the above-mentioned embodiment of the present invention, and that the balun in accordance with the present embodiment has a [2-splitting] two-way splitting function. However, in addition to these configurations, a balun circuit having three or more coupling lines and an ~~N-splitting~~ N-way splitting function may also be used.

Page 21 First Full Paragraph Bridging Pages 21 and 22:

Next, a fourth embodiment of the present invention will be described below referring to the accompanying drawing. FIG. 7 is a view showing a balun in accordance with the fourth embodiment of the present invention. Referring to FIG. 7, the numerals 2010, 2020, 2030, 2040 [to 2040] designate first to fourth dielectric layers, the numeral 2050 designates

an input line, the numerals 2060, 2070 designate first and second main line portions, the numerals 2080, 2090 designate first and second coupling lines, the numerals 2100, 2110 designate first and second output line pairs, the numerals 2120, 2130, 2140, 2150, 2160 [to 2160] designate first to fifth through holes, and the numerals 2170, 2180, 2190, 2200, 2210 [to 2210] designate first to fifth grounding conductors. [It is supposed that the] The first to fifth grounding conductors 2170, 2180, 2190, 2200, 2210 [to 2210] are connected electrically to one another via through holes or the like (not shown). Among the above-mentioned electrodes and lines, the electrodes and lines disposed on the same plane form each of layers, and these layers correspond to the conductor pattern layers in accordance with the present invention. These conductor pattern layers are alternately stacked with the first to fourth dielectric layers 2010, 2020, 2030, and ~~to~~ 2040 to form the multilayer in accordance with the present invention. In addition, the first and second main line portions 2060, 2070 and the second through hole 2130 used to connect the first and second main line portions form the main line in accordance with the present invention. [It is supposed that the] The coupling degree between the first main line portion 2060 and the first coupling line 2080 is the same as that between the second main line portion 2070 and the second coupling line 2090.

Page 22, Last Paragraph Bridging Pages 22 and 23:

It has been described that two coupling lines are used in the above-mentioned embodiment of the present invention, and that the balun in accordance with the present embodiment has a [2-splitting] two-way splitting function. However, in addition to these

configurations, a balun circuit having three or more coupling lines and an N-splitting function may also be used. In this case, a plurality of main line portions may be disposed on the same conductor pattern layer wherein the plural main line portions may not be connected directly to one another on the conductor pattern layer.

Page 23, Last Paragraph Bridging Pages 23, 24 and 25:

Next, a fifth embodiment of the present invention will be described below referring to the accompanying drawing. FIG. 8 is a view showing the configuration of a balun in accordance with the fifth embodiment of the present invention. Referring to FIG. 8, the numerals 3010, 3020, 3030, 3040, 3050 [to 3050] designate first to fifth dielectric layers, the numeral 3060 designates an input line, the numerals 3070, 3080 designate first and second main line portions, the numerals 3090, 3100 designate first and second coupling lines, the numerals 3110, 3120 designate first and second output line pairs, the numerals 3130, 3140, 3150, 3160, 3170 [to 3170] designate first to fifth through holes, the numerals 3180, 3190, 3200, 3210, and to 3220 designate first to fifth grounding conductors, and the numeral 3230 designates a shield conductor layer. The [It is supposed that the] first to fifth grounding conductors are connected electrically to the shield conductor layer 3230 via through holes or the like (not shown). Among the above-mentioned electrodes and lines, the electrodes and lines disposed on the same plane form each of layers, and these layers correspond to the conductor pattern layers in accordance with the present invention. These conductor pattern layers and the shield conductor layer 3230 are alternately stacked with the first to fifth dielectric layers 3010 to 3050 to form the multilayer board in accordance with the present

invention. In addition, the first and second main line portions 3070, 3080 and the second through hole 3140 used to connect the first and second main line portions to each other form the main line in accordance with the present invention. The coupling degree between the first main line portion 3070 and the first coupling line 3090 is the same as that between the second main line portion 3080 and the second coupling line 3100.

Page 25, Third Full Paragraph:

It has been described that two coupling lines are used in the above-mentioned embodiment of the present invention, and that the balun in accordance with the present embodiment has a [2-splitting] two-way splitting function. However, in addition to these configurations, a balun circuit having three or more coupling lines and an ~~N-splitting~~ N-way splitting function may also be used. In this case, a plurality of main line portions may be disposed on the same conductor pattern layer wherein the plural main line portions may not be connected directly to one another on the conductor pattern layer.